

The first 20 minutes in the Hong Kong stock market

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Abstract

Based on the minute-by-minute data of the Hang Seng Index in Hong Kong and the analysis of probability distribution and autocorrelations, we find that the index fluctuations for the first few minutes of daily opening show behaviors very different from those of the other times. In particular, the properties of tail distribution, which will show the power law scaling with exponent about -4 or an exponential-type decay, the volatility, and its correlations depend on the opening effect of each trading day.

Key words: Probability distribution; Volatility; Autocorrelation; Exponential; Power law.

1 Introduction

Recently, detailed analysis on the high-frequency financial market data has shown that there exist some universal statistical characteristics for price or index fluctuations, in particular the fat tail distribution and rapid decay of correlation for price changes, and the persistence of long-range volatility correlation [1–4]. For one of these fundamental features, the probability distribution, the power-law asymptotic behavior with an exponent about -4 has been found from the daily and high-frequency intra-daily stock market data [3,4].

Many efforts have been made to simulate the market behaviors and dynamics, and then to reproduce these stylized observations of real markets. Much work focuses on the microscopic discrete models [5–9], with different mechanisms based on the intrinsic structure of financial markets, including the herding and

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imitation behaviors [6,8] as well as the mutual interactions [7] among market participants.

The other way to model the dynamics of financial markets is using the approach of continuous stochastic process and then, e.g., determining the effective stochastic equation for price evolution [10–12]. Based on the analysis of Hang Seng Index (HSI) in Hong Kong and the method of conditional averages proposed for generic stationary random time series and previously applied in fluid turbulence [13], a Langevin equation reproducing well both the observed probability distribution of index moves with fat tails and the fast decay of moves correlation has been derived [10]. The existence of a viscous market restoring force and a move-enhanced noise is shown in the equation. Moreover, an analytic form for the whole range of probability distribution has been obtained, and interestingly, the corresponding asymptotic tail behavior is an exponential-type decay:

$$P(x) \sim \exp(-\alpha|x|)/|x|, \quad (1)$$

where the index move $x(t) = \text{index}(t) - \text{index}(t - \Delta t)$ with time interval Δt (e.g., 1 min), faster than the power law behavior with exponent about -4 found in recent studies [3,4,7,8]. The parameters can be directly determined from the market data (in which the first 20 minutes in the opening of each day are skipped), and the tail behavior (1) has also been observed in the simulations of our self-organized microscopic model [9] with social percolation process [14,15], which is proposed to describe the information spread for different trading ways across a social system.

Instead of describing the details of our modelings for financial market behaviors which have been or will be published elsewhere [9,10], here we present our work on the analysis of Hang Seng Index (HSI), showing that the properties of probability distribution and volatility correlations for index fluctuations depend on the opening effect of each trading day (i.e., the overnight effect), which can also explain the above difference between the exponential-type fat tail behavior derived in our Langevin approach [10] and the recent empirical findings of -4 power law distribution [3,4].

2 Probability distribution

The HSI data we used contains minute-by-minute records of every trading day from January 1994 to December 1997, and the break between the morning and afternoon sessions as well as the difference between trading days are considered in our analysis. First, we skip the data in the first 20 minutes of each morning

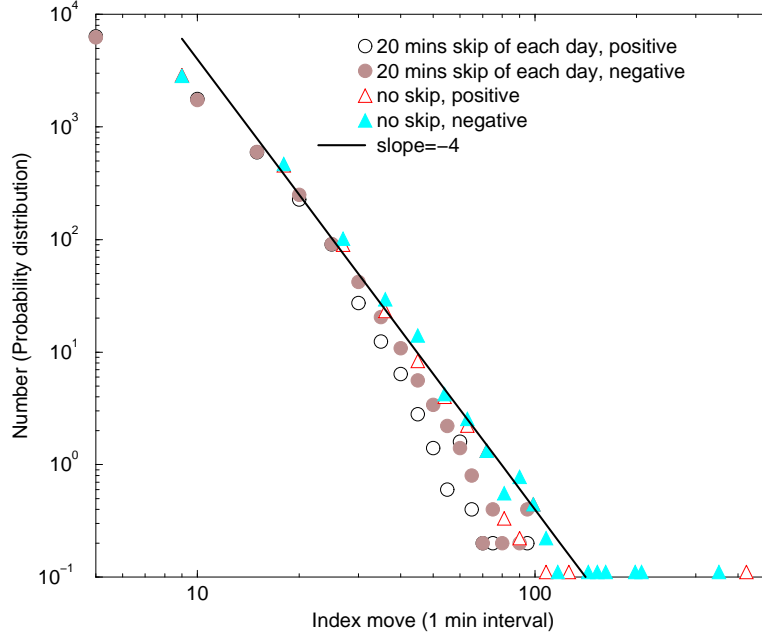


Fig. 1. Log-log plot of the probability distribution of 1 min index moves for the Hang Seng Index (HSI) from 1994 to 1997 (open: positive tails, filled: negative tails). The distributions with the skip of first 20 minutes in daily opening (circles) and without skip (triangles) are shown.

session, i.e., skip the opening of each trading day, and the deviation from -4 power law in the tail region of the distribution for 1 min interval index moves is found (Fig. 1, circles). In this case the -4 power law seems to be a crossover effect within a limited range, and for large index moves the log-log plot exhibits curvature, corresponding to the exponential-type Eq. (1) derived from the Langevin approach [10].

Next, we analyze the data without any skip in daily opening, and it is interesting to find that the -4 power law scaling is recovered for 1 min interval, as shown in Fig. 1 (triangles), which is in agreement with recent observations from German share price index DAX [3] and S&P500 index [4].

This phenomenon shows the importance of the daily opening or overnight effect for the properties of stock market. It is well known that price fluctuations in the opening of trading day are highly influenced by exogenous factors, and the studies on trading volume have exhibited the larger and less elastic transactions demand at opening and close times compared with that at other times of the trading day [16]. Very recently, it has been observed from the German DAX data that due to the peculiarity in the calculation of the opening index with the mixture of overnight and high-frequency price changes, the first

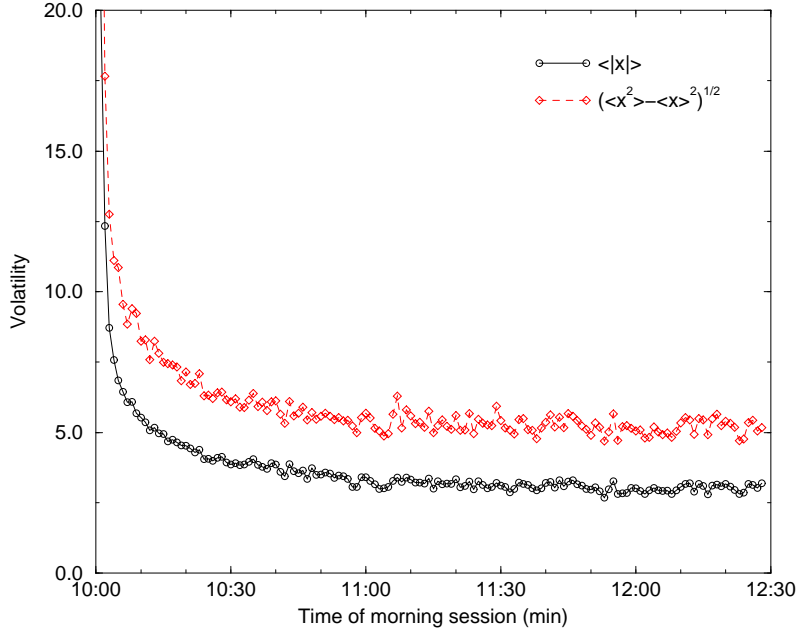


Fig. 2. The mean of the absolute value of index moves x and the volatility for different times of morning session (open at 10:00) in Hong Kong stock market, where the averages are over different trading days at the same time.

observations of each day are governed by the process different from that of the other times [17]. However, a power law scaling with exponent between 4 and 5 is found for DAX data in [17] when the first 15 minutes of every day are dropped, instead of the exponential-type behavior here.

3 Volatility and autocorrelations

For HSI data it is found that the values of index moves and the volatility at the daily opening times are much larger than those of other times. Fig. 2 shows the mean of the absolute value of index moves $\langle |x| \rangle$ and the volatility $(\langle x^2 \rangle - \langle x \rangle^2)^{1/2}$ for different times of morning session (open at 10:00), where the averages are over different trading days from 1994 to 1997 at the same minute. Both of the values are obviously larger for the first 20 minutes, and then remains almost unchanged at late times, similar to the phenomena of German DAX data [17]. Thus, when skipping the opening data, much less extreme values of index move are calculated in the probability distribution, and consequently, the far tail of distribution may decay faster, as seen in Fig. 1.

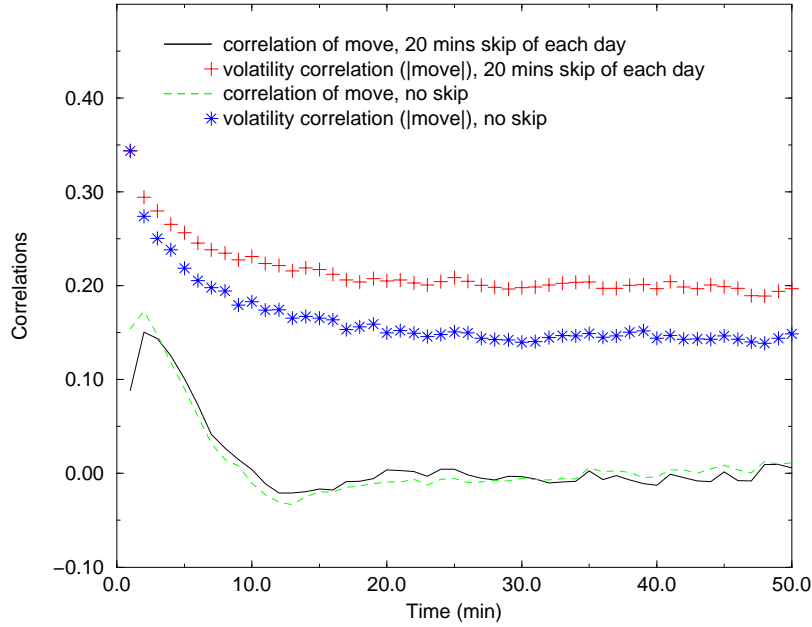


Fig. 3. Autocorrelations of the index moves and the absolute value of index moves (volatility correlations) for HSI data.

Here we find that the different behavior of distribution shown in Fig. 1 is relevant to the different properties of volatility clustering. Fig. 3 shows the autocorrelations of index moves and volatility for 1 min interval, with and without the skip of first 20 minutes, where the correlation for the index move x

$$C(T) = \frac{\langle x(t)x(t+T) \rangle - \langle x(t) \rangle^2}{\langle x(t)^2 \rangle - \langle x(t) \rangle^2} \quad (2)$$

rapidly decays to zero in about 10 minutes, and the persistence of long-range volatility correlation,

$$V(T) = \frac{\langle |x(t)||x(t+T)| \rangle - \langle |x(t)| \rangle^2}{\langle |x(t)|^2 \rangle - \langle |x(t)| \rangle^2}, \quad (3)$$

(averaged over the whole index time series) is found, in accordance with the previous studies [1,2]. The correlations of moves present little difference with or without the skip, however, the volatility correlation with no skip (Fig. 3, stars) is obviously smaller. This decrease is due to the fact that the volatility correlations of the first few minutes in the daily opening are much smaller than those of other times, as given in Fig. 4. Note that Hong Kong stock market

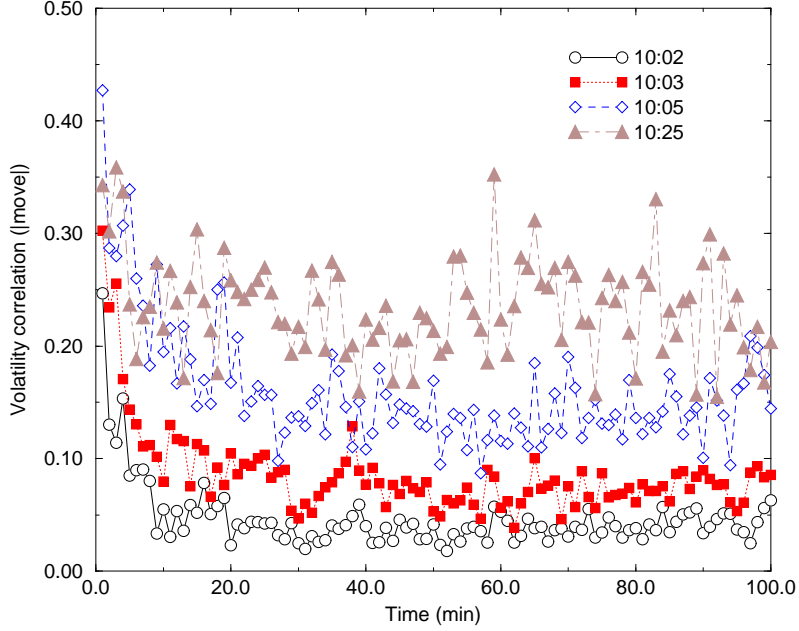


Fig. 4. Volatility correlations (for the absolute value of index moves) for different times: 10:02, 10:03, 10:05, and 10:25 of Hong Kong stock market.

opens at 10:00 in the morning, and Fig. 4 shows the volatility correlations of different times, defined as

$$V(t_o, T) = \frac{\langle |x(t_o)| |x(t_o + T)| \rangle - \langle |x(t_o)| \rangle \langle |x(t_o + T)| \rangle}{\langle |x(t_o)|^2 \rangle - \langle |x(t_o)| \rangle^2}, \quad (4)$$

which is similar to Eq. (3), but averaged only over different days (at the same time t_o) in the period of 1994-1997. In the opening time region, the value of correlation increases with the increasing of time, and after the opening (about 20 minutes, i.e., 10:20), the correlation keeps relatively unchanged (with the values around the pluses of Fig. 3).

The absolute value of index move is used to calculate the volatility correlations in the above study, as shown in Eqs. (3) and (4). If using the square of move instead, the values of correlation are found to be smaller, but the above results will not change, as shown in Figs. 5 and 6.

It is known that the Hong Kong stock market behaved abnormally during the second half of 1997, due to the much more significant impact of external conditions. When we discard the data of 1997 and only study the market from 1994 to 1996, the results are the same as above.

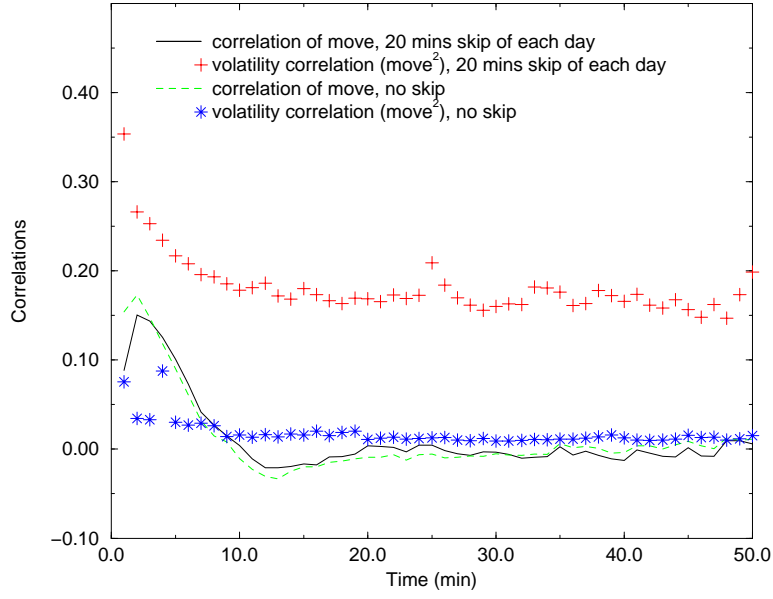


Fig. 5. Autocorrelations of the square of index moves (volatility correlations) for HSI data. Correlations of index moves are also shown for comparison.

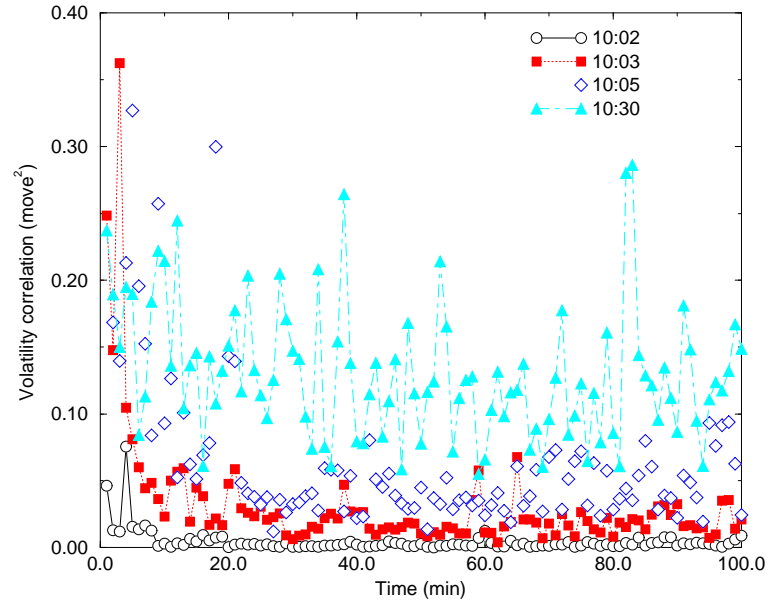


Fig. 6. Volatility correlations (for the square of index moves) for different times: 10:02, 10:03, 10:05, and 10:30 of Hong Kong stock market.

4 Summary

In this work we have presented that the index fluctuations for the first few minutes of daily opening behave very differently from those of the other times, and the lower degree of volatility clustering at the opening can affect the behaviors of fat tail distribution: -4 power law behavior if including the daily opening data, or the exponential-type if not. To further understand these properties of HSI market data, more work is needed to study the details of the opening procedure of stock market.

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References

- [1] J.-P. Bouchaud and M. Potters, Theory of Financial Risk, Cambridge University Press, Cambridge, 2000.
- [2] R. Mantegna and H.E. Stanley, An Introduction to Econophysics: Correlations and Complexity in Finance, Cambridge University Press, Cambridge, 1999.
- [3] T. Lux, Appl. Financial Economics 6 (1996) 463.
- [4] P. Gopikrishnan, V. Plerou, L.A.N. Amaral, M. Meyer, and H.E. Stanley, Phys. Rev. E 60 (1999) 5305 .
- [5] M. Levy, H. Levy, and S. Solomon, Microscopic Simulation of Financial Markets, Academic Press, New York, 2000; J. Physique I 5 (1995) 1087.
- [6] R. Cont and J. P. Bouchaud, Macroeconomic Dynamics, in press; e-print, cond-mat/9712318.
- [7] T. Lux and M. Marchesi, Nature 297 (1999) 498.
- [8] D. Stauffer and D. Sornette, Physica A 271 (1999) 496.
- [9] Z.F. Huang, Eur. Phys. J. B, in press (2000).
- [10] L.H. Tang and Z.F. Huang, preprint.

- [11] R. Friedrich, J. Peinke, and C. Renner, Phys. Rev. Lett. 84 (2000) 5224.
- [12] C. Vamos and N. Suci, preprint.
- [13] S.B. Pope and E.S.C. Ching, Phys. Fluids A 5 (1993) 1529; G. Stolovitzky and E.S.C. Ching, Phys. Lett. A 255 (1999) 11.
- [14] S. Solomon, G. Weisbuch, L. de Arcangelis, N. Jan, and D. Stauffer, Physica A 277 (2000) 239.
- [15] Z.F. Huang, Int. J. Mod. Phys. C 11 (2000) 287.
- [16] W.A. Brock and A.W. Kleidon, J. Econ. Dyn. Control 16 (1992) 451.
- [17] T. Lux, Appl. Financial Economics, in press.